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An Integrated Approach to Teach 3-D AutoCAD Crossing the Boundary of Architectural History

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Abstract

It seems there is a boundary line between the disciplines of modern technology and history. Can these two be interrelated and interact on each other? The answer is yes. Generally speaking, 3-D AutoCAD is taught in a traditional way which means students follow the tutorial text book and learn the software without any cultural or historical content. The projects and exercises for students are focused on learning the commands and technology only. This study is to explore a new integrated approach to teach 3-D AutoCAD. It necessitates interdisciplinary dialogue and collaborative action across the boundaries of courses taken by architectural and interior design students within the engineering technology department. In this 3-D AutoCAD course, the learning of Roman architecture history is reinforced. Students are expected to create a hybrid interior space with Roman architectural components. Roman architectural materials are introduced to students for their design and appreciation. The purpose of this new teaching method is not only to teach 3-D rendering software for construction of a realistic model for a new design concept, but also to teach students reconstruction of ruined ancient Roman buildings with real materials and lightings. Furthermore, historical reflection will be addressed through the integration enhancing student knowledge of Roman architecture.

This paper presents the results of assessment for this integrated approach of teaching 3-D AutoCAD and makes recommendations to the university community for future 3-D AutoCAD teaching. Many issues related to integration of computer technology and architecture history were discovered which will provide valuable information for future course format and content not only for AutoCAD courses, but also for architecture history courses as well as architecture and interior design studio courses.

I. Introduction

Traditional 3-D AutoCAD Course Format and Content

In traditional 3-D AutoCAD course, instructors only demonstrate new commands to students without any graphic images and architecture reviews. There is no introduction and appreciation of culture and design. It is a computer technology only course. The typical project is to create a commercial or residential space without any cultural or historical reflection requirement in the design. The only outcome of this learning process is that students learned how to use 3-D AutoCAD to generate a 3-D model for a new design concept. The traditional 3-D AutoCAD course teaching model can be described as the following:

1. Step one: basic 3-D AutoCAD command demonstration by the instructor
2. Step two: students follow the tutorial text book working on the assignment which is so-called in class exercise
3. Step three: students work on the project without any cultural or historical reflection requirement
4. Step Four: Advanced 3-D project without any cultural or historical reflection requirements on project.

The Rationale of Integrated Approach to teach 3-D AutoCAD

The integrated approach of teaching 3-D AutoCAD is to engage in the dialogue between architecture history and the built environment. This dialogue is facilitated and completed by the computer software. In this computer technology course, 3-D AutoCAD became the tool to undertake this task that facilitates the dialogue between architecture history and the built environment. There is something significant to the history of architecture, and that is architecture's ability to tell powerful stories. It is believed that architecture and its interior space remain the most powerful way of creating meaningful space [2]. Now there are many architecture and interior spaces that show a complete lack of cultural content and historical reflection. These spaces rely on forms to create so-called cutting-edge environment that is created by industrialized and standardized worldwide use of building materials and construction methods. This design approach neglects and destroys local building traditions [6].

Furthermore, modern information technology and the rapid spread of computer-aided design to all fields of architecture and interior design, has helped to free-up a designer's creative processes. With the latest three-dimensional design software it is much easier to design and model sophisticated and complex shapes and forms. Computer tools shaping architectural creations are not a new method. In the 20th century, architecture made a big departure from its previous history: on one side, material science has permitted the use of former impossible forms and, on the other side, CAD tool has released the creativity of designers. Ancient, classical and traditional architecture (Roman and Greek Temples and some instances of modern architecture (Frank Lloyd Wright) describe forms using simple addition and subtraction of spheres, polyhedron and simple solids (cube, cone, cylinders,) [1]. It is obvious that CAD has been used to create shapes and forms beyond designer's ability. Therefore, the theory and fact stated above strongly support this integrated approach.

II. Preparation of Integrated Approach

Rome, Italy Study Abroad Course

There is a study abroad course INTR 220 Architecture and Urban Forum within the Department of Civil & Architectural Engineering Technology at Indiana University Purdue University Fort Wayne. This course has been its 15th year this summer. It is a two weeks study abroad course and is open to all students and professionals. Students can also earn 3 credits to fulfill general education (Area IV Humanities Thoughts) requirement. The course provides an intense

introduction to ancient Roman architecture and the interior space of significant temples and churches as well as architecture history and construction methods. To take advantages of this course, Roman architecture components and ancient Roman ruins become the major course subjects in 3-D AutoCAD to address cultural and historical reflection. In Fall 2004 semester, there were seventeen students in 3-D AutoCAD class and four of them had been to Rome, Italy during summer 2004. As the instructor of 3-D AutoCAD, the author had the opportunity to teach this course last year and used the traditional course format and contents. As one of the instructors of Rome study abroad course, the author also had the chance to travel to Rome, Italy and investigate the Roman architectural components and ancient Roman ruins while teaching INTR 220 on site. It was a good preparation for the development of a new integrated 3-D AutoCAD course. It is definitely an advantage for the author who developed the integrated 3-D AutoCAD course to have first hand information with Roman architecture.

Field Data Collection
To explore Roman architecture, a study trip to Rome, Italy was taken during July 8 – July 22, 2004. Field data was collected by the author in the form of digital pictures of Roman architecture and its' components. Roman interior space, decorative materials, and the ruins of the Baths of Caracalla were studied intensively. In addition, freehand sketches and field measurements were recorded while teaching Roman architecture on site.

Render Library Development and Pre-Test
After returning from Rome, Italy, a render library with authentic Roman architectural material was created before the new semester started. To categorize Roman architectural components and authentic materials into a CAD render library, digital images were imported into AutoCAD. The CAD render library was used to build a model of a portion of the Baths of Caracalla as a pre-test of this newly developed CAD render library. It was used in the integrated 3-D AutoCAD course as a demonstration for students.

III. Description of Integrated Approach

Integrated Course Format
This new integrated course format is different from the traditional 3-D AutoCAD course format. The major difference is that it integrates culture and historic components in the course to reinforce student's knowledge of Roman architecture. There is a culture vs. design introduction and appreciation associated with student projects. The projects students created reflect cultural and historical meaning through the interior spaces. Students also learned how to reconstruct ancient Roman ruins with digital 3-D model. The integrated approach can be described as follows:

1. Step one: basic 3-D AutoCAD commands demonstration by the instructor
2. Step two: pre-test 3-D model (portion of Bath of Caracalla) demonstration created by instructor

3. Step three: Roman architectural components and authentic Roman architectural materials appreciation through digital file. Digital images were collected from Rome trip during the summer.
4. Step four: initial hands on experience – a hybrid interior space (Roman architecture spirit reflection in a modern built environment)
5. Step five: hands on experience – Reborn of Pompeii (digital method of building 3-D model to represent ancient Roman ruins with authentic Roman architectural materials)

Course Design and Students Projects
The students are expected to build basic Roman architectural components such as column orders, triangular pediment, vaults and arches by using the new commands they learned in the class. The first project is to create a hybrid interior space by using Roman architecture components. The final project is to reconstruct a ruined house in Pompeii. The authentic Roman architectural materials in the format of digital file were posted on the network for students to use when they worked on their final project. The architectural components created in the previous class session are to be used in the final project. The render library of authentic Roman architectural materials and finishes, as well as lighting design, is to be demonstrated and applied to the 3-D models.

The First 3-D project – A Hybrid Interior Space is to create a hybrid interior space of conference room. This conference room is inside a historical building at downtown Chicago. This historical building features Roman architectural components, such as Roman column orders, arch windows, dome ceiling, etc. You will find mosaics and marbles as well as stain glass window inside the building. The client wants to redesign their conference room to represent the spirit of Roman architecture in a modern urban setting. Students were also told by the project description that it is believed a good design needs to have culture content and historical reflection. The built environment has the power to tell the story and conveys the meaning. Students are expected to create a hybrid interior space of Roman architecture and modern construction.

The followings are design requirements for this 3-D project of the conference room:
1. A conference table with at least six chairs
2. Need a countertop for serving refreshment and drinks
3. Need a display case for company's products
4. Need window view facing the street
5. There are two existing columns (Doric Order) at the entrance
6. Need a screen for tele-conference
7. Ceiling could be a dome, curved ceiling; coffer ceiling; floating ceiling or any other type of ceilings.
8. Use 3D AutoCAD to create a 3D rendering for this space.
9. You may choose appropriate finishes for this interior space. Please design lighting for this room also.
10. Please refer to attached plan for dimensions. (an attached floor plan with dimensions were given to the students)

The Second 3-D project – Reborn of Pompeii is to create a digital 3-D model to represent ruined House of Vettii in Pompeii. Pompeii is the world's oldest archaeological dig. It has been under excavation more or less continually since 1748, and two-thirds of the town has been stripped of the Vesuvian ash that buried it on August 24, A.D. 79. Researchers have searched beneath Pompeii's mosaic floors for evidence of its origins and early development. To represent Pompeii's hidden past has become a task for architects, designers and archaeologists. Using 3-D software to reconstruct this famous Roman resort is not a new task, but has become more and more feasible and promising by the revolution of computer technology. Students were also told the project description: You have been assigned with this task to construct a 3-D model for HOUSE OF THE VETTII – One of the finest and most luxurious of Pompeii. The decoration of the rooms is still in excellent condition. 3-D AutoCAD has the power to undertake this task. The authentic materials should be imported into the CAD library. Lighting applications should be used in the interior space to present this "Reborn of Pompeii" project.

The followings are design requirements for this project:

1. Need to use authentic materials (fresco, mosaic……)
2. Floor plan and dimensions are shown as attached (an attached floor plan showing existing conditions with dimensions were given to students)
3. Please create 3-D model for the courtyard / garden (e) as shown within dashed line
4. Please create 3-D model for the atrium (d) as shown within dashed line
5. Create perspective views for both courtyard (e) and atrium (d), two for each at least
6. Please design the lightings for interior space also.
7. Please use you judgment and imagination when the data is uncertain.
8. All digital files are posted on the network for you to use. (digital images from past exploration were posted on the network for students)

Sample of student works of first 3-D project and second 3-D project can be found in Appendix.

IV. Expected Learning Outcomes

Comparison of Traditional Course Format and Integrated Course Format
The differences between traditional 3-D AutoCAD course format and integrated 3-D AutoCAD course format and learning outcomes can be seen from the following diagrams:

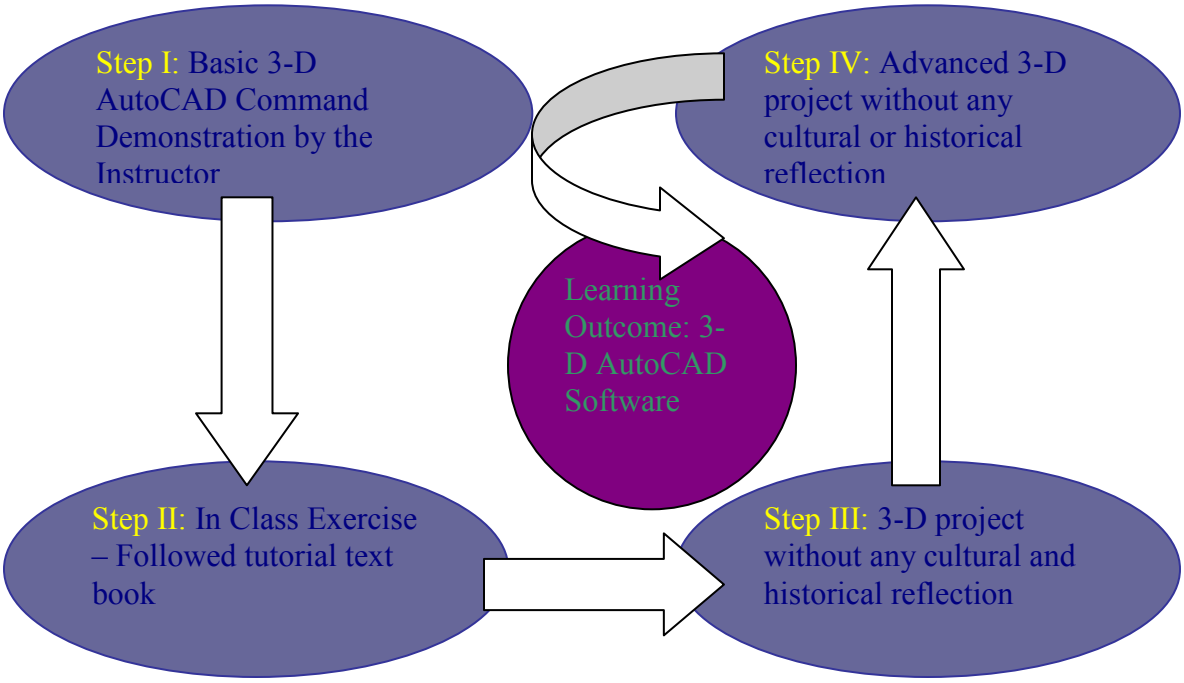

Figure 1-1: Traditional 3-D AutoCAD Course Format and Learning Outcome

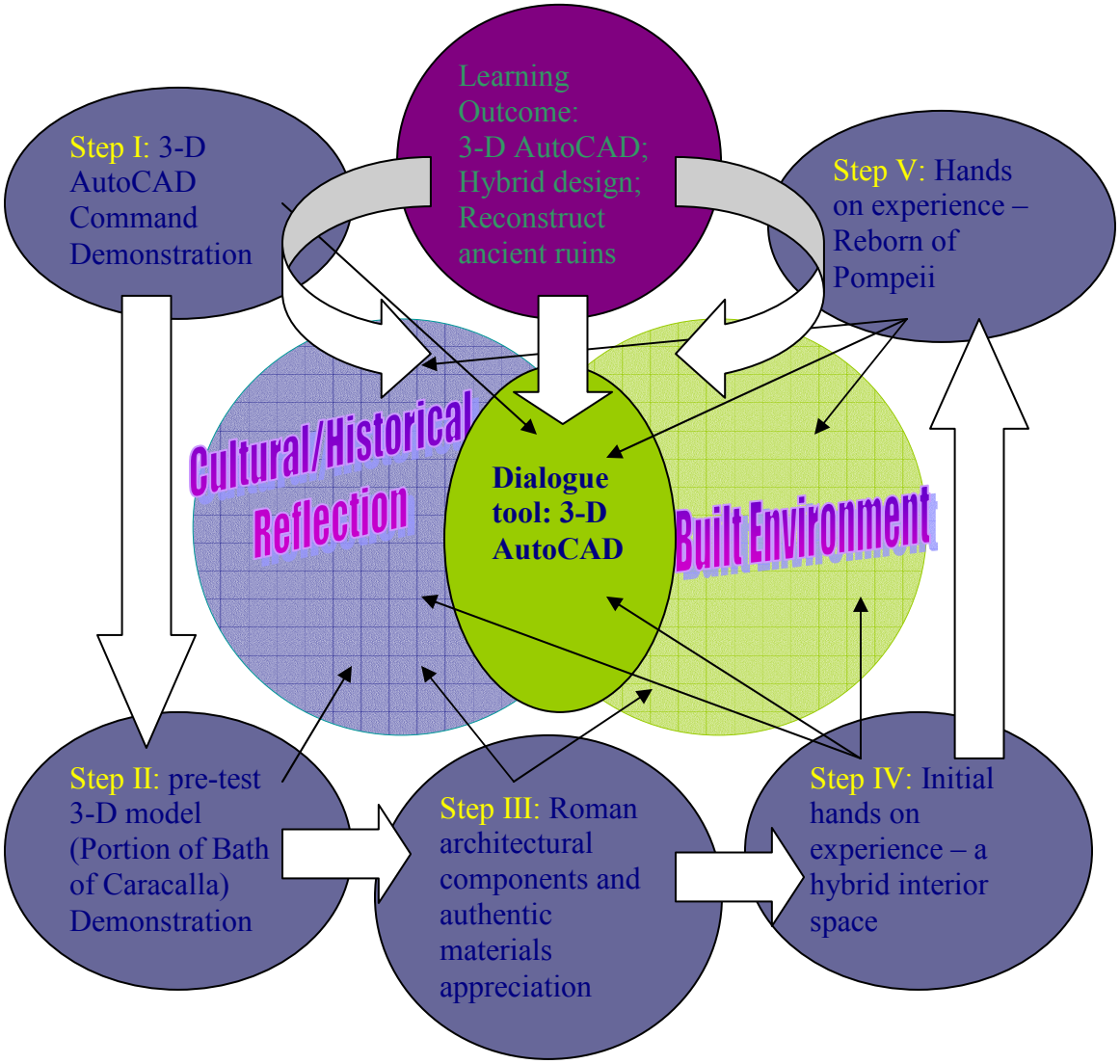

Figure 1-2: Integrated 3-D AutoCAD Course Format and Learning Outcome

Expected Learning Outcomes

It is clear that the expected learning outcomes from the integrated 3-D AutoCAD course can be described as the followings:

- Students learn the 3-D AutoCAD software and are able to create digital 3-D models for a new design concept. This is a necessary skill for a designer during the schematic design phase. Students can use this skill to interact with clients by presenting 3-D images with realistic materials and lighting design. This outcome is also the only learning outcome from the traditional 3-D AutoCAD course format.
- The course reinforced the student's knowledge of Roman architecture. Since the integrated 3-D AutoCAD course addressed cultural and historical reflection by Roman architectural components and authentic Roman architectural materials, students had the opportunity to be exposed to architecture history especially Roman architecture. Students were able to apply Roman architecture components in the design.
- Students are able to create a hybrid interior space which requires historical reflection. It is also a good opportunity for students to have hands-on experience of creating a hybrid interior space. It is just like a studio project but it needs to reflect cultural and historical content. The digital 3-D model becomes the tool to convey the design concept. Students not only created the design but also learned the 3-D software.
- Students are able to create digital 3-D models to represent ancient ruins with authentic architecture materials. Using 3-D model to reconstruct ancient Roman architecture is not a new task. It becomes more and more promising with the revolution of computer software. 3-D AutoCAD has the power to undertake this task and students learned the skill to build digital 3-D models by importing authentic Roman architectural materials to the material library.

V. Assessment Methodology

Student response towards the new course format is an important factor in the assessment of student learning. An extensive survey was developed and conducted to assess the student response towards the learning outcomes. The four expected learning outcomes were measured by questionnaire. The following list of questions indicates the student responses measured for each learning outcome.

***Understanding of 3-D AutoCAD software before/after taking this course**

1. can build realistic models with real materials and lightings
2. can reconstruct ruined ancient buildings
3. can build realistic models with authentic materials by importing digital images
4. can build real landscape and people figures

*** Reinforce the student's knowledge of Roman architecture**

5. Reinforce my knowledge of Roman architecture
6. Have practical experience of integrating classical architecture components in a design solution
7. Have you taken architectural or interior design history course before you take this class?

*** Hybrid interior space with cultural and historical reflection**

8. I like the integration of humanities into the computer technology course
9. I like the design projects with culture and historical reflection instead of just software command learning
10. I like the design projects with experiential learning of culture content in the built environment
11. Not only learned how to build 3-D model, but also learned how to design a space with culture reflection
12. Roman architectural components in design
13. Integrating Roman architectural components with modern design
14. Culture and historical reflection in the design
15. Understand of theory of culture and historical reflection in the built environment

*** Digital 3-D model to represent ancient Roman ruins**

16. Not only learned how to build a 3-D model with the materials in the material library, but also learned how to import a new material from digital images
17. Importing authentic materials and apply them to the 3-D model.
18. Using digital images in the material library
19. To reconstruct ruins and show their original materials
20. There are limitations of using physical models.

Open end questions:

1. What did you learn from the project "A Hybrid Interior Space"?
2. What did you learn from the project "Reborn of Pompeii"?

Seventeen students participated in the class and thirteen survey responses were received along with general response from the last two open end questions. The survey was anonymous and no attempt was made to correlate response to student project outcomes in the

course. The survey was voluntary and there is no obligation for students. A percentage scale was used for all survey items except open-end questions.

VI. Results and Discussion

The survey questions and responses were summarized and grouped together to measure each of four learning outcomes. The following bar graphs show the percentage of questions for each learning outcome that was measured. Then the mean (average percentage) was calculated for each group questions.

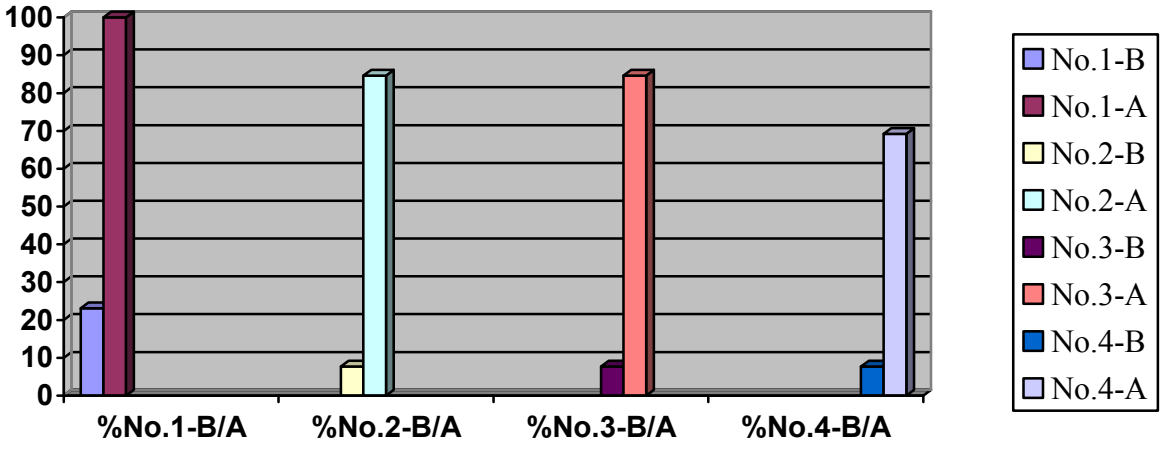

Figure 2-1: Comparison of understanding of 3-D AutoCAD Before (B) and After (A) taking the course

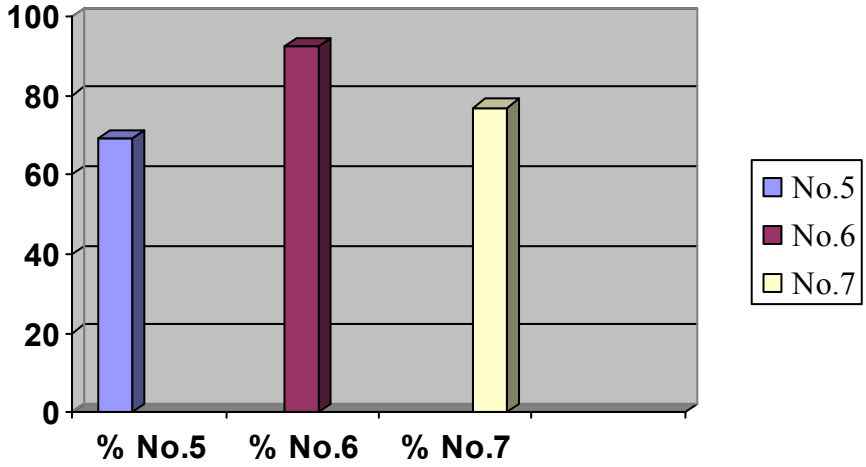

Figure 2-2: Reinforce student's knowledge of Roman architecture

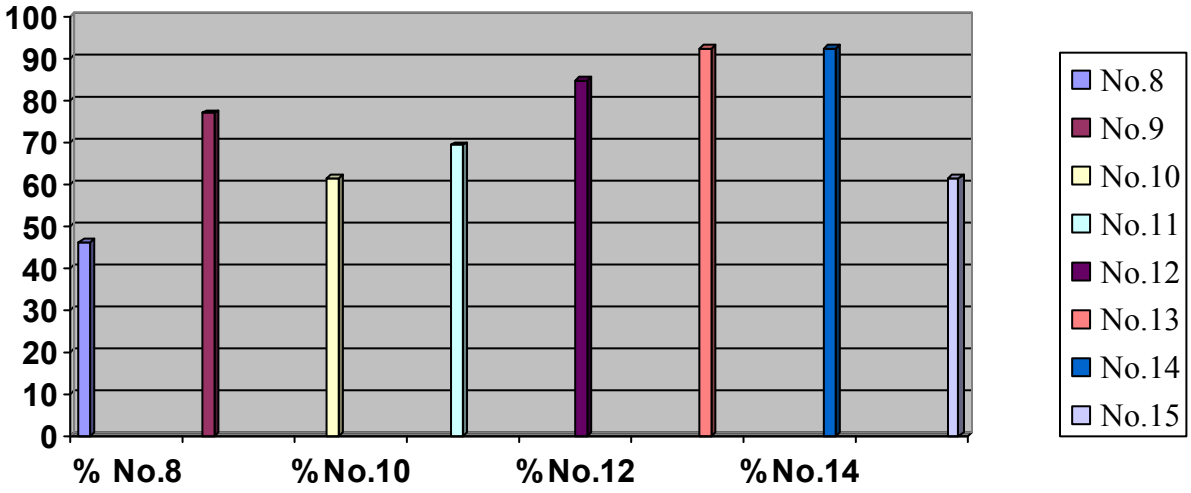

Figure 2-3: Hybrid interior space with cultural and historical reflection

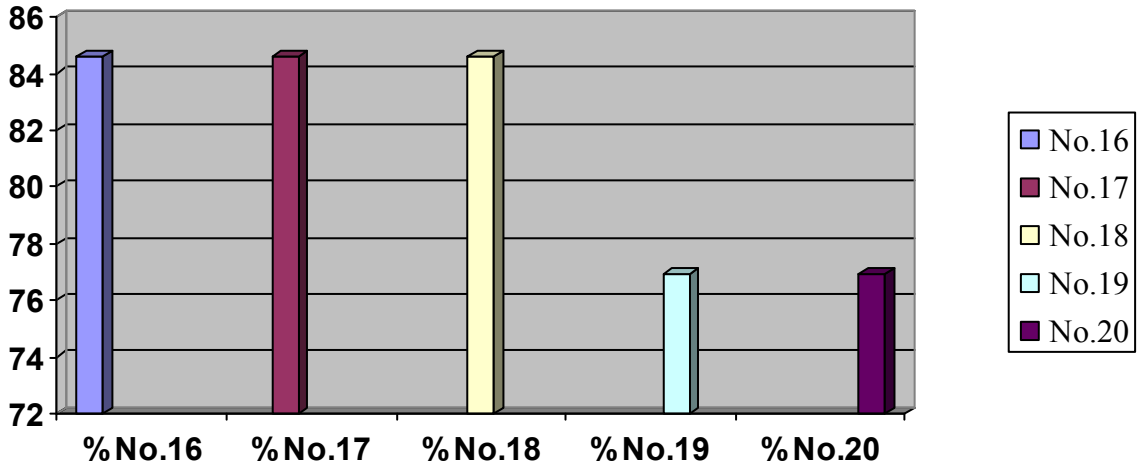

Figure 2-4: Digital 3-D model to represent ancient Roman ruins

Four learning outcomes were measured. Question No.1 – No.4 measured student's knowledge of AutoCAD before and after taking 3-D AutoCAD course. Same questions were asked regarding students understanding of 3-D AutoCAD before and after taking the course. The Figure 2-1 presents the comparison of survey results. The average percentage (mean) of four questions before taking the course was only 7.7%. But after taking the course, the average percentage (mean) of four questions increased to 80%. This is a very positive response, which indicates students reached the goal of learning outcome. Question No.5 – No.7 measured learning outcome of reinforcing student's knowledge of Roman architecture. Figure 2-2 presents the percentage of each response. The average percentage (mean) of three responses is 79.5%, which is very positive. Question No.8 – No.15 measured learning outcome of understanding hybrid design with cultural and historical reflection. Figure 2-3 presents the percentage of each question. The response of question No.8 "I like the integration of humanities into the computer technology course" is negative. However, the average (mean) of these eight questions is 73%, which is quite positive. It indicates that the third learning outcome was achieved. Question No.16 – No.20 measured the fourth learning outcome of reconstruction of ancient Roman ruins. The figure 2-4 presents the percentage of response from each question. The average percentage (mean) of those five questions is 81.5%, which indicates a positive response. It means the fourth learning outcome was reached.

The overall response from the students in the integrated course was quite positive. Additional comments provided by the students gave insight into problem areas not addressed by the questionnaire. Some very positive comments that were not addressed in the questionnaire were also received. The followings are the typical feedbacks from the questionnaire:

- The project assignments are very good projects and very interesting
- I learned a lot from the 3-D project especially reconstruction of ancient ruins
- I learned a lot from every aspect of building 3-D models
- I learned a lot from the course especially from two 3-D projects – A Hybrid Interior Space and Reborn of Pompeii.
- I learned how to apply materials that aren't normally in the materials library.
- I learned how to incorporate Roman architectural components into office space
- I am having fun while working on the projects.
- I just want to learn the software and don't like the project with cultural / historical reflection requirement. (only a few students stated so)

These comments in addition to results presented in this paper, will provide the academic community some guidance for future action. The following list summarizes the most significant result and observation:

- The instructor must commit time and resources to create projects to address cultural and historical reflection issues.
- The integrated 3-D AutoCAD course reinforce the student's knowledge of Roman architecture

- Students not only learned 3-D AutoCAD software, but also learned how to create a hybrid interior space with cultural and historical reflection
- Students learned to reconstruct digital 3-D model to represent ancient Roman ruins with authentic architectural materials
- Students learned how to import digital files to material library
- Students like the project "a hybrid interior space"
- Students like the project "reborn of Pompeii"
- Students were very proud of their projects they accomplished

In addition to the questionnaire, a final class presentation took place at the end of the semester. Faculty members and professional expert were invited to the classroom to review student projects and provide comments. Feedbacks were very positive as well.

The author's observations of student behavior both in and out of class concur with the results of the student questionnaire. The author as an instructor was very pleased with outcomes of student projects. The level of complicity and creativity exceed the level of previous year's student work.

Several problem areas were identified. The most significant was the sequence of two 3-D projects. It was advised that the second 3-D project (Reborn of Pompeii) should be the first one because it is just the transformation of built environment into digital 3-D model with application of material library. "A hybrid of Interior Space" should be the second 3-D project because it requires both creativity and 3-D transformation. It is also an experiential learning of integration of classical architectural components in the design.

This problem is easy to remedy. There will be a small project before the proposed first 3-D project "Reborn of Pompeii". This small 3-D project will introduce material library and digital file importing. Students will be able to apply real and authentic materials on 3-D models.

VII. Summary and Recommendations

This new approach of teaching AutoCAD reinforces student's knowledge of Roman architecture. In the meantime, students learned the digital method to reconstruct ancient Roman buildings by using 3-D AutoCAD. This carefully crafted computer technology course also enables historical and cultural reflection. This new pedagogy consents to the conclusion that engineering students need some type of humanities based education.

There are other case studies strongly support the conclusions of this integrated approach. For example, History of Science and Technology course taught in other institution is an excellent example. It is an integrated approach to teach history in the engineering curriculum. Through this History of Science and Technology course, students will not only be able to identify events that characterize the history of western science and technology, but also be able to think critically and comprehensively about the world that derived from these events. Many other universities have had this type of course in their curriculum.

The following are recommendations from this case study and assessment:

- Integrating architectural history components into computer technology course
- Continuing development of course format and students projects
- This integrated approach can be used in architecture history course to reinforce knowledge of classical architecture.
- It can also be adopted by design studio course to address cultural and historical reflection in an urban setting
- This integrated approach of crossing the boundary of architectural history also can be adopted by other architectural engineering courses, such as Construction Systems and Materials, Architectural Engineering Construction, Construction Graphic Communications and Environmental Equipment. The integrated components could be an analysis of significant architecture of a famous architect such as Frank Lloyd Wight, Mies Van der Rohe and Le Corbusier. For instance, Mies Van der Rohe's famous International Exposition at Barcelona can be introduced in Construction Graphic Communication course. The floor plan of the International Exposition at Barcelona could be an assignment for students to learn how to draft. From this project, students can learn drafting while they can learn other design theories such as "Flowing Space" and "Less is More". Frank Lloyd Wright's Falling Water can be introduced in a Construction System and Materials course. Different material applications on the house and special structure components used in order to sport the big cantilever above the cliff could be an excellent example to address the course subject matter.

Findings of this study and scenarios for future courses to cross the boundary of architectural history can be summarized as the following diagram:

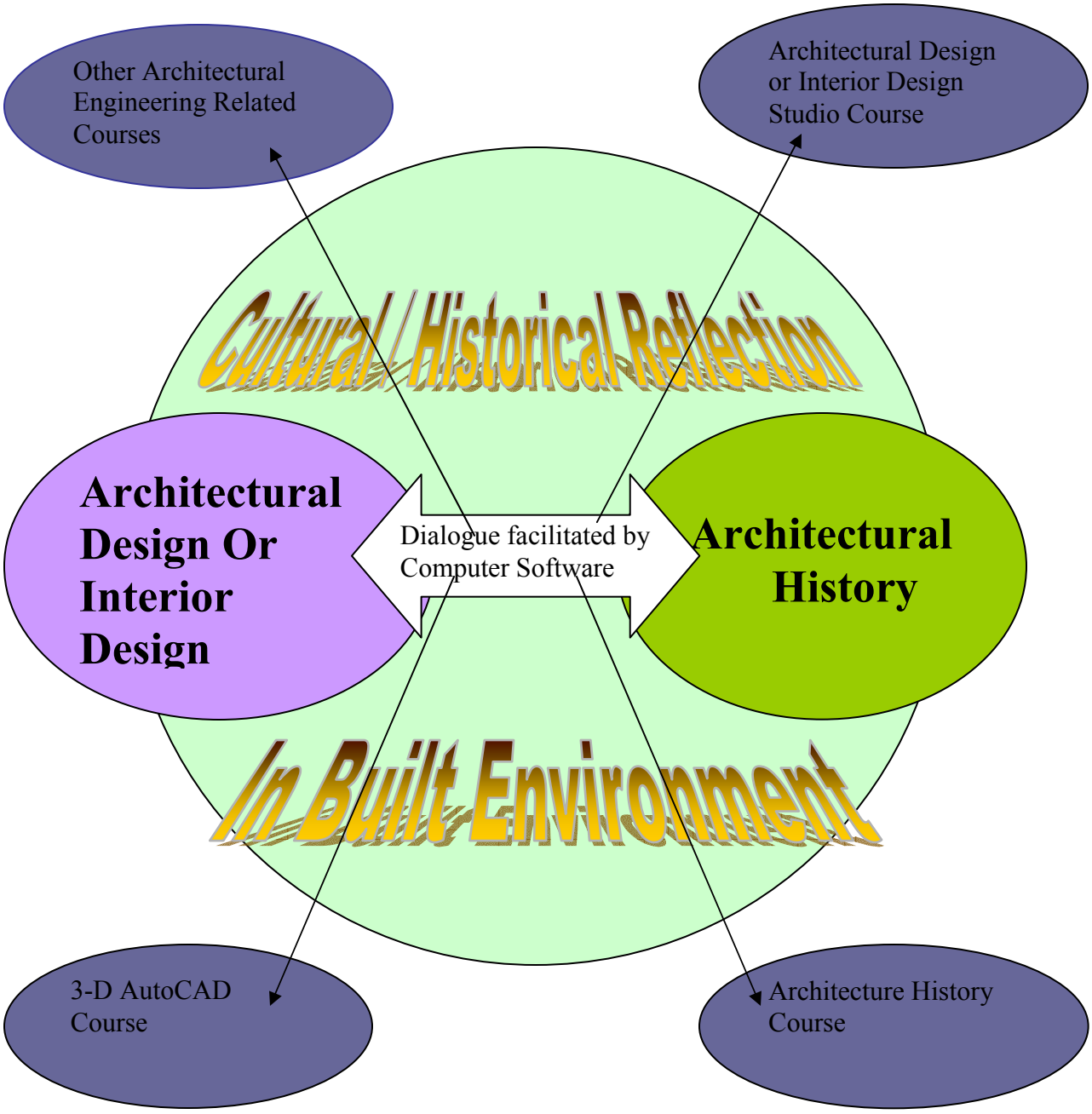

Figure 3-1: Scenarios for Future Courses to Cross the Boundary of Architectural History

The above recommendations are also based on the typical course format of architecture history. It was taught by either lecture or slide presentation. This passive approach didn't give students opportunity to have hands on experience to work on classical architecture. Some architecture schools taught students to draw classical column orders or classical architecture components by manual drafting to reinforce the knowledge of classical architecture. However, by the revolution of computer software, it is absolutely wise to adopt technology into the architecture history course and take advantage of computer software. On the other hand, design studio course is taught with projects barely with any cultural and historical reflection. It will be changed with this integrated approach.

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Biographies

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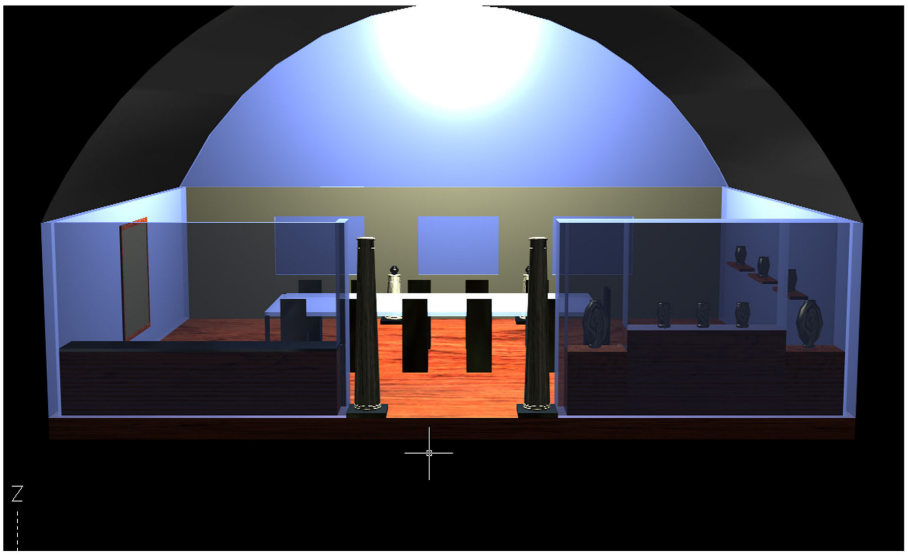
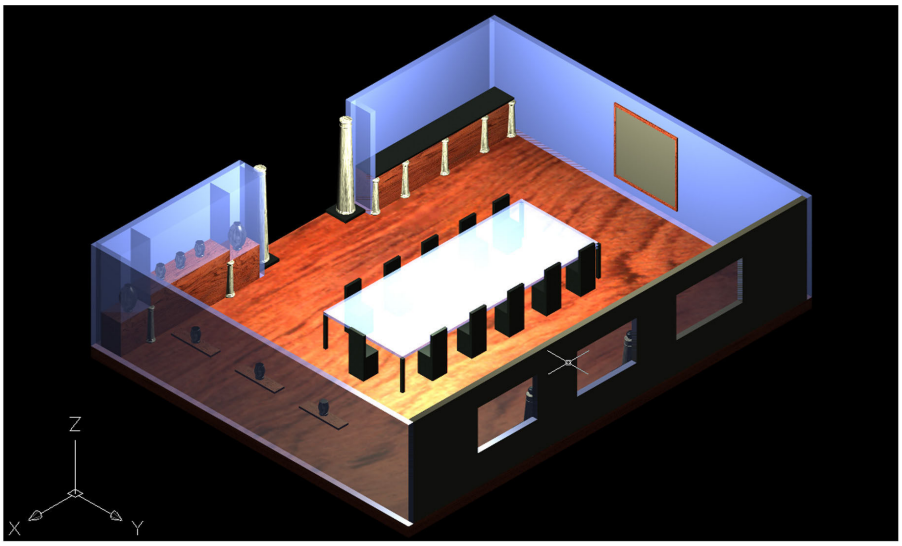
Appendix





Appendix I: Sample of Student Work “A Hybrid Interior Space”

Appendix II: Sample of Student Work "Reborn of Pompeii"